Chapter 7

Herpetofauna of Montane Areas of Tanzania. 3. Amphibian Diversity in the Northwestern Eastern Arc Mountains, with the Description of a New Species of *Arthroleptis* (Anura: Arthroleptidae)

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Abstract

Amphibians of the Eastern Arc Mountains are poorly known, apart from those of the East Usambara, Uluguru, and Udzungwa Mountains. Here, we detail specimens collected in the northwestern Eastern Arc Mountains (West Usambara, South Pare, and North Pare) over the past 100 years. Although not comprehensive, the list is compiled from specimens held at institutions in Europe and the United States and in personal collections; it includes most of the specimens known from this area. From these specimens, we describe one new species of the frog genus *Arthroleptis* and discuss other specimens that may represent new species. We add substantially to the known diversity in these areas. Using the compiled species list, we assess species diversity and relate the differences to sampling bias and possible biogeographic differences among the mountains. The future preservation of amphibians across this area is of concern given the increasing loss of forest.

Introduction

East African mountains are noted for their high levels of biodiversity (e.g., Burgess et al., 2007). In northern Tanzania, the East Usambara section of the Eastern Arc Mountain chain (EAM) has been a focus of collecting for a century (Howell, 2000) and shows a high degree of endemicity that has made it one of the main conservation priorities in the region. Northwest of the East Usambara, the EAM continues as three mountain ranges showing topographical complexity: the West Usambara, South Pare, and North Pare (Fig. 1). These have a similar geological origin to the East Usambara mountain complex (Griffiths, 1993) and contain evergreen rainforest assemblages (Howell, 1993; Lovett, 1993). These three blocks have received only patchy attention and are poorly understood biologically compared with the East Usambara (Burgess et al., 2007). This is particularly true of the amphibian fauna (Grandison, 1983), which has proved to be conspicuously rich in the EAM (Poynton et al., 2007; Andreone et al., 2008). The primary aim of this paper is to consolidate our knowledge of amphibian diversity in these three mountain regions and thus highlight this relatively poorly studied area.

The first notable herpetological collections from the EAM were made by early German explorers around the turn of the 20th Century (Howell, 2000). The focus, as today, was mainly in areas around the East Usambara (Grandison, 1983), principally in and around Amani, a German medical field station. The earliest herpetological collections made in the West Usambara were in Philipshof (=Magamba, near Lushoto, West Usambara, Tanzania), Mombo (Nieden, 1915) and Ambangulu (reported in Nieden, 1913; Bauer et al., 2006). But not until Barbour and Loveridge's (1928) pivotal paper on the fauna of the Uluguru and Usambara Mountains were the amphibians northwest of the East Usambara discussed explicitly. Loveridge collected most intensively in the East Usambara but also sampled areas in the West Usambara (Philipshof and Bumbuli). Loveridge recorded only two and eight species, respectively, from these localities (Barbour & Loveridge, 1928). After this period, there was a hiatus in herpetological collecting in this area.

From 1970 onward, short surveys have been made fairly frequently in the West Usambara Mountains (Grandison, 1983). Among specimens recorded in this paper are collections by A. G. C. Grandison, who surveyed Mazumbai in 1973; K. M. Howell collected in the 1980s and 1990s; R. C. Drewes and J. V. Vindum of the California Academy of Sciences surveyed Mazumbai Forest Reserve (FR), Baga II FR, and Lushoto FR in 1988; A. Schiøtz surveyed Mazumbai during the 1970s

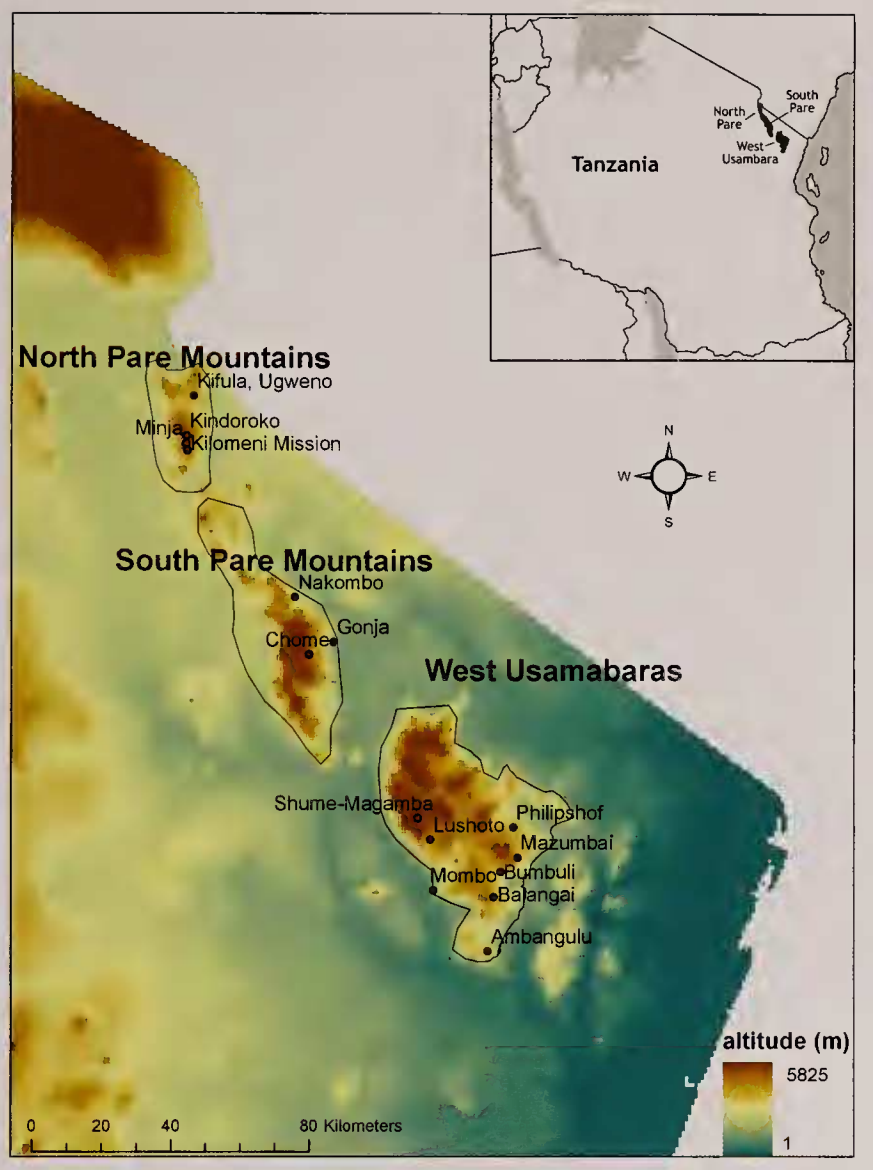

FIG. 1. Map of the northern Eastern Arc Mountains of Tanzania.

through 1990s; J. Rasmussen, M. Anderson, and M. Vestergaard surveyed Mazumbai in 1992; W. T. Stanley and S. M. Goodman from the Field Museum of Natural History (FMNH, Chicago, IL) surveyed Ambangulu at various times between 1991 and 1993; M. Coe collected specimens in the West Usambara; A. Channing and R. O. de Sá surveyed Mazumbai FR in 2000 and 2009; S. P. Loader and J. Mariaux surveyed Mazumbai in October 2001; S. P. Loader, J. Mariaux, and D. J. Gower surveyed Ambangulu in May 2002; and a combined FMNH and MCZ (Museum of Comparative Zoology, Cambridge, MA) expedition conducted by L. Lawson, L. Mahler, and B. Zimkus (2007) surveyed Mazumbai, Shume-Magamba, and Ambangulu. Other surveys may have been conducted but remain unknown to us.

The amphibians and reptiles of the Pare Mountains have received substantially less attention. K. M. Howell and C. A. Msuya made the first surveys in the North Pare in the 1970s and into the 1980s. N. Cordeiro made collections of amphibians in the North Pare in July 1993, and at the same time, W. T. Stanley and S. M. Goodman from FMNH and C. A. Msuya of the University of Dar es Salaam, Tanzania, surveyed the South Pare. A year later, W. T. Stanley made further collections at higher altitudes in the South Pare. An Mkomazi Ecological Research Programme collected two species in the South Pare outside the Mkomazi Reserve, Tanzania. Most recently S. P. Loader, J. Mariaux, and D. J. Gower of BMNH (Natural History Museum, London) and MHNG (Muséum d'histoire naturelle de Genève) and M. Menegon of Trento Museum (2007–2008) surveyed the North and South Pare.

From the surveys conducted in the West Usambara and Pares, the geographical distributions of a number of species have been extended (summarized in Howell, 1993; Burgess et al., 2007), and eight amphibian species have been described: *Arthroleptis lonnbergi* Nieden, 1915; *Hyperolius tanneri* Schiøtz, 1982; *Arthroleptis tanneri* Grandison, 1983; *Callulina kisiwamsitu* de Sá et al., 2004; *Arthroleptis fichika* Blackburn, 2009; *Callulina laphami* Loader et al., 2010; *Callulina stanleyi* Loader et al., 2010; and *Callulina shengena* Loader et al., 2010. In total, four species are endemic to the West Usambara, three species to the South Pare including our new *Arthroleptis*, and one species to the North Pare.

Given the number of surveys, it might be assumed that we have a relatively good understanding of the amphibians in this region, particularly the West Usambara. However, the recorded distribution of many taxa across the Eastern Arc is currently confused and certainly incomplete (Poynton et al., 2007); thus, records of even reputedly common species should be re-examined closely. By citing specimens and their locality data, we intend to establish a comprehensive list of amphibians of West Usambara and Pare Mountains. Additionally, we describe one new species and outline specimens putatively identified as being distinct and not assignable to any currently described taxon. All specimen identifications were made either by authors of the paper or communicated to us by colleagues (A. Channing and B. M. Zimkus). This list is therefore necessarily preliminary—detailed taxonomic assessment is still required in some taxa. Overall, we aim to establish a thorough summary of taxonomic information on the amphibians in this area, which we hope will encourage researchers to conduct further field surveys and detailed taxonomic work on specimens from these mountains.

Materials and Methods

Material was examined from the following institutions or personal collections: Alan Channing Field Series (AC); Natural History Museum, London (BMNH); California Academy of Sciences, San Francisco (CAS); Field Museum of Natural History, Chicago (FMNH); Lucinda Lawson Field Series (LL); Museum of Comparative Zoology, Harvard University (MCZ); Muséum d'Histoire Naturelle, Geneva (MHNG); Museo Tridentino di Scienze Naturali, Trento (MTSN); University of Michigan Museum of Zoology, Ann Arbor (UMMZ); United States National Museum, Washington, D.C. (USNM); Humboldt-Universität, Zoologisches Museum, Berlin (ZMB); Zoological Museum of Copenhagen (ZMUC). The taxonomy largely follows that of Frost (2010), with the exception of several new species that were described recently (Loader et al., 2010). Some *Arthroleptis* specimens could not be identified, either because of poor state of preservation or because they are juveniles. The specimens we were unable to identify include: CAS 169383–93, Baga II FR; CAS 173798, Mazumbai FR; CAS 200511–12, Mazumbai FR. A gazetteer lists all localities given for each specimen (degrees, minutes, seconds); elevation (m) is provided when known. Certain localities visited on multiple occasions are numbered to differentiate between each one (e.g., Ambangulu FR, Mazumbai FR, and Chome FR). Further specific details of these localities are given in the gazetteer section.

List of the Amphibians of the West Usambara and South and North Pare Mountains

Order Anura
Family Arthroleptidae
***Arthroleptis* spp.**

Arthroleptis is one of only three genera of widespread African frogs for which comprehensive taxonomic and geographic sampling has been attempted for a molecular phylogenetic analysis (Blackburn, 2008), the others being *Xenopus* and *Plurynobatrachus* (Evans et al., 2004; Zimkus et al., 2010). Blackburn (2008, 2009a) revealed that *Arthroleptis* species from the EAM and elsewhere in East Africa represent at least two radiations. Taking morphological characters also into account, one radiation comprises miniature species (snout–vent length < 25 mm) with small inner metatarsal tubercles not (or barely) longer than the length of the subarticular tubercles; EAM species include *A. xenodactylus, A. xenodactyloides, A. fichika*, and *A. kidogo*. Another radiation comprises medium- to large-sized species with inner metatarsal tubercles at least twice as large as the subarticular tubercles (but not longer than the first toe); representatives in the EAM are *A. affinis, A. reichei*, and *A. nguruensis*. Another species in this region with an inner metatarsal tubercle longer than the first toe is represented by *A. stenodactylus*. We describe here a species that exhibits morphology intermediate between that of the two recognized clades, thus making its relationship obscure. This new species is even more exceptional in lacking an externally visible tympanum; instead, the otic region is fully occupied by jaw musculature.

***Arthroleptis anotis* sp. nov.**
Figure 2a–d, dorsal, and lateral views

Holotype—BMNH 2000.732 (field number KMH 19583), a gravid female collected 19 November 1999 by K. M. Howell in the Chome Forest Reserve, South Pare Mountains, Tanzania, ca. 1900 m elevation, 4°18′S, 37°53′E (see Fig. 2a,d).

Paratype—BMNH 2000.731 (field number KMH 19581), a female with developing ova collected 19 November 1999 by K. M. Howell in the Chome Forest Reserve, South Pare Mountains, Tanzania, ca. 1900 m elevation, 4°18′S, 37°53′E.

Diagnosis—A miniature *Arthroleptis* (snout–vent length < 25 mm) that is distinguished from all other *Arthroleptis* (sensu Blackburn, 2008) by lacking an externally visible tympanum (see Fig. 2b,c). In other respects, the species presents typical *Arthroleptis* features (e.g., Frétey, 2008; Zimkus & Blackburn, 2008) by having a dorsal skin ridge (or "raphe"), a dorsal "hourglass pattern," and large unpigmented eggs; lacking interdigital pedal webbing; and having only one metatarsal tubercle (i.e., inner metatarsal tubercle).

Measurements of Holotype (and Paratype)—Measurements taken by one researcher (J.C.P) using mechanical calipers accurate to 0.1 mm. Snout–urostyle length (SUL) 22.9 mm (20.2 mm), snout–vent length 23.6 mm (21.2 mm), head width 18.8 mm (17.9 mm), internarial distance 2.8 mm (2.4 mm), tibia length 10.5 mm (9.4 mm), foot length 10.2 mm (9.4 mm), length of inner metatarsal tubercle 1.0 mm (1.0 mm), oval in shape, not ridged, length of other pedal subarticular tubercles less than 0.9 mm, inner toe length 1.6 mm (1.2 mm), length of fourth toe 5.7 mm (5.6 mm), length of third finger 3.0 mm (2.9 mm). Tips of fingers and toes slightly expanded with rounded discs, toe discs with circum-marginal grooves; disc width on toe four 0.6 mm, width of distal tubercle of toe four 0.4 mm, disc width on finger three 0.5 mm, width of distal tubercle of finger three 0.4 mm (toes and fingers desiccated, compromising accuracy of measurement). Diameter of eggs 2.1 mm.

Description of Holotype—No externally visible tympanum; tympanic area occupied by extensive adductor musculature with no tympanic membrane or columella evident. Reflected skin shows no tympanic impression. Tongue heart-shaped, no median papilla, no vomerine teeth, premaxillary and maxillary teeth present. Inner metatarsal tubercle ovoid and not projecting as a flange. Interocular area to rostral tip light-colored with some darker flecks. Dorsal skin ridge marked by a light line. Markings include a pair of light, diverging post-scapular patches, a pair of dark patches beside the ilia, and a dark transverse bar on each crus. Dark band extending behind eye to above the region that would normally be occupied by tympanum to level of jaw articulation. In ventral view, gular region immaculate, pectoral region with dark brown spots, most of abdomen darkened by a single large brown patch.

Variation—The paratype agrees morphologically with the holotype. The snout is lighter in color, but with more flecks present than in the holotype (see Fig. 2e,f). As in the holotype, the paratype exhibits the dorsal hourglass pattern typical of many *Arthroleptis*, but with a larger light area in the scapular region that extends on to the sides. A dark patch extends along either side of the ilia. The gular, pectoral, and abdominal regions are almost immaculate in the paratype.

Coloration in Life—No description of the color in life of the holotype was provided. The paratype was described as being brown with a relatively darker brown hourglass pattern on the dorsum and a red-orange venter.

Natural History—The only two specimens were collected from the leaf litter in montane forest in Chome Forest Reserve through casual visual surveys. There is no information regarding any other aspects of its biology (e.g., calls, behavior).

Conservation Status—*Arthroleptis anotis* is currently known only from Chome Forest at ca. 1900 m. If its distribution is restricted to the South Pare Mountains (maximum estimated forest cover between 139 to 333 km^2; Table 2), then it should be considered of high conservation concern.

Etymology—The specific epithet derives from Greek (*an-*, without; *otos*, ear) and relates to the fact that this is the only species of *Arthroleptis* known to lack an externally visible ear.

***Arthroleptis affinis* Ahl, 1939**

Records—**WEST USAMBARA**, MCZ A-13167 (Philipshof).

Remarks: Until very recently, all medium- to large-sized *Arthroleptis* in the MCZ collections from the EAM were identified as *Arthroleptis adolfifriederici*, a species with a complicated taxonomic history (Blackburn et al., 2009). These misidentifications contributed to erroneous distribution maps for *A. adolfifriederici* in a recent review of East African amphibians (Channing & Howell, 2006; K. Howell, pers. comm.); these specimens even included one designated as a paratype of *A. tanneri* by Grandison (1983). Poynton and Loader (2008) did not record specimens of *A. affinis* from the West Usambara or Pare Mountains but pointed out the many taxonomic difficulties with large-bodied *Arthroleptis* in the

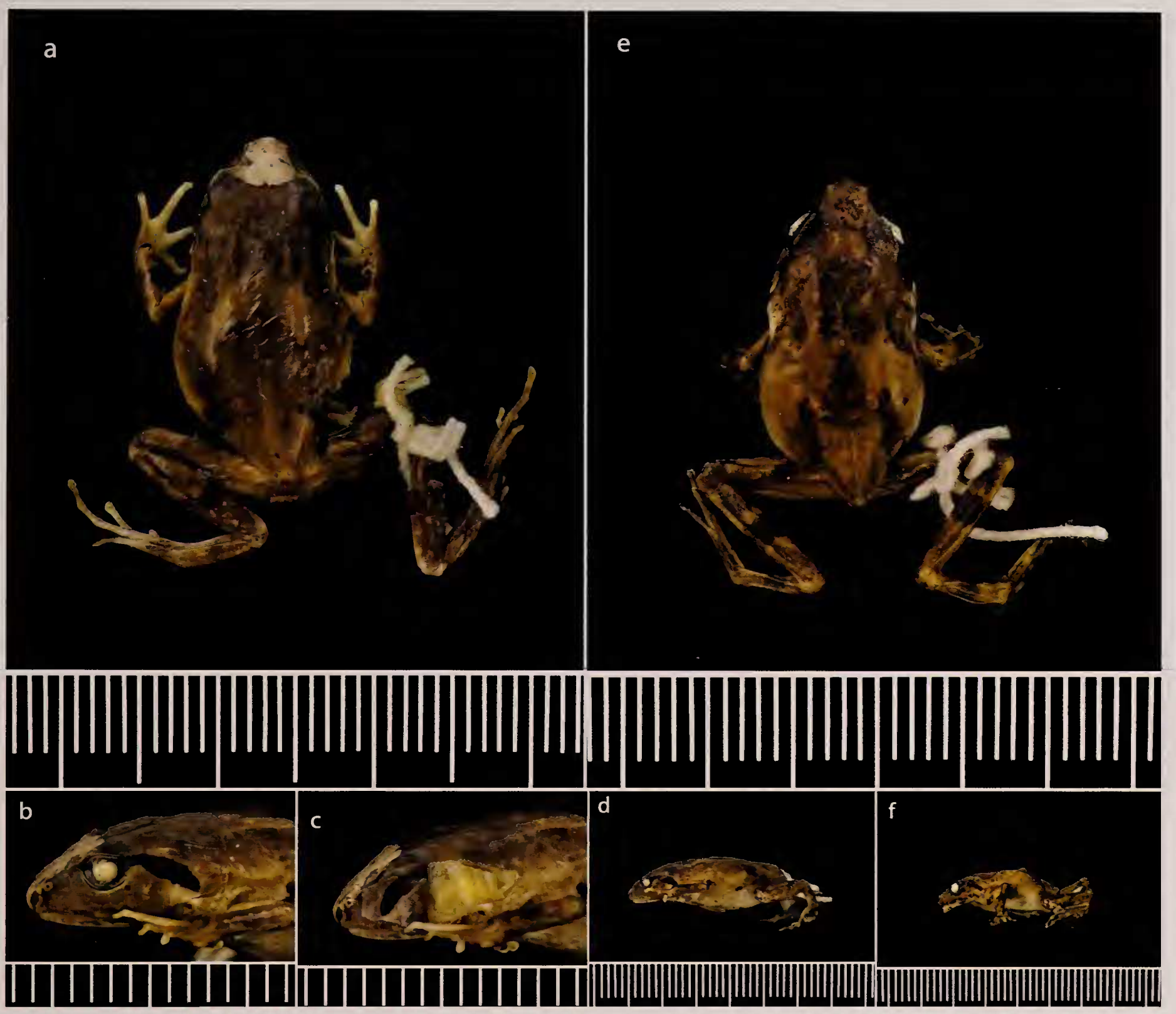

FIG. 2. Photographs of *Arthroleptis anotis* n. sp. in dorsal, and lateral view of head: (**a–d**) Holotype (BMNH 2000.732): (**e, f**) paratype (BMNH 2000.731). Scale bar = 1 mm.

EAM. The single male specimen (MCZ A-13167; 27.8 mm snout–vent length) recorded here from the West Usambara, which was collected alongside a paratype of *A. tanneri* (Barbour & Loveridge, 1928), is, to our knowledge, the only specimen from these mountains that is morphologically similar to *A. affinis*, the type locality of which is in the East Usambara.

***Arthroleptis fichika* Blackburn, 2009**

RECORDS—**WEST USAMBARA**, MCZ A-138384 (Mazumbai FR I); AC 2209, AC 2211 (Mazumbai FR II); BMNH 1974.225–28 (Mazumbai FR II); CAS 168829 (paratype; Baga II FR); **SOUTH PARE**, FMNH 251864 (Chome FR V); **NORTH PARE**: BMNH 2005.950 (Kindoroko FR).

REMARKS: This species was recently described by Blackburn (2009a), who noted that a single specimen (FMNH 251864) from the South Pare was highly genetically divergent (16.7%) from West Usambara populations of *A. fichika* with which it formed a clade in phylogenetic analysis. This single specimen was tentatively included in *A. fichika*, though it likely represents another cryptic species of miniature *Arthroleptis*. We add new specimen records of *A. fichika* from the type locality from Grandison's Mazumbai collection (BMNH 1974.225–228) and Channing's collection (AC 2209, 2211). Because several of these new records are males and the description of *A. fichika* was based only on females, we provide data on male traits. Of Grandison's four specimens, one is a male, BMNH 1974.227, snout–urostyle length 12.5 mm. The third finger is 2.0 mm long (16.4% SUL). The SUL of the females ranges from 15.1 to 14.3 mm; the length of the third finger ranges from 2.1 to 1.9 mm (average 13.5% SUL). The third finger of the male has several spines on the medial and dorsal surfaces; the second finger has fewer spines. One specimen (AC 2211; 13.9 mm snout–vent length) has small spines typical of *Arthroleptis* on the medial surface of the third finger (three on the right and approximately two on the left), but there is no evidence of spines in the inguinal region as

in many other *Arthroleptis* (Blackburn, 2009b). There is no obvious dimorphism in third finger length when comparing AC 2211 (12.9% of snout–vent length) to the female type specimens (11.1% and 13.3%). Furthermore, one specimen collected in the North Pare Mountains is tentatively included under this species. With just a single specimen and lack of DNA sequence data, the taxonomic evaluation of this population is preliminary, especially given the genetic differences between populations from the type locality and those from populations on other mountains (Blackburn, 2009a).

***Arthroleptis lonnbergi* Nieden, 1915**

Records—**WEST USAMBARA**, ZMB 24535 (holotype; Mombo).

Remarks: Recently, Pickersgill (2007) used call data to justify the resurrection of *A. lonnbergi* based on specimens from the East Usambara (Kambai and Longuza Forest Reserves) that are reportedly morphologically similar to *A. stenodactylus*. Unfortunately, these specimens are not (to our knowledge) deposited in a collection that is available for study. Thus, it is unclear whether specimens considered *A. stenodactylus* here correspond to *A. lonnbergi* (sensu Pickersgill, 2007). In addition, this resurrection was done without reference to the type and only specimen of *A. lonnbergi* (ZMB 24535) but rather because it was "the earliest applicable name [Pickersgill] could find." It should be noted that *A. lonnbergi* was erected by Nieden (1915) for a single specimen that he noted was morphologically similar to *A. stenodactylus* in all features except that it lacked a median tongue papilla. This is incorrect as examination of the holotype (probably an immature female; 29.6 mm snout–vent length) reveals a prominent median papilla at approximately a fourth of the distance to the posterior margin of the tongue. The specimen also has a prominent inner metatarsal tubercle, although it is not longer than the first toe as in most specimens of *A. stenodactylus*. We include this specimen in our account because the type locality is given by Nieden (1915) as "Mombo in Usambara," which is a town (ca. 440–460 m elevation) located at the base of the West Usambara. However, it is not impossible that the holotype of *A. lonnbergi* was collected in the mountains. Rather than redesignating *A. lonnbergi* as a junior synonym of *A. stenodactylus*, we take the position that further study employing detailed and statistical morphological analyses are needed to address possible cryptic diversity within *A. stenodactylus* and its past or present junior synonyms.

***Arthroleptis stenodactylus* Pfeffer, 1893**

Records—**WEST USAMBARA**, FMNH 248019 (Ambangulu FR III); MCZ A-13139 (Bumbuli), A-138370–79, A-138381 (Mazumbai FR I); **SOUTH PARE**, FMNH 251441–42 (Gonja FR), 251881, 255891 (Chome FR V).

Remarks: *Arthroleptis stenodactylus* is a widespread East African species occurring in forests, savanna woodlands, and even near urban areas, such as the campus of the University of Dar es Salaam (K. M. Howell, pers. comm.). This species has several junior synonyms, but until recently, there has been little investigation of patterns of diversity among populations referred to *A. stenodactylus* based on morphological evidence. Blackburn (2008) found that although *A. stenodactylus* was monophyletic, it contained one of the highest levels of intraspecific genetic divergence of the *Artlıroleptis* species surveyed in that study.

***Arthroleptis tanneri* Grandison, 1983**

Records—**WEST USAMBARA**, BMNH 1974.59 (holotype; Mazumbai FR II), 1974.50–63, 1974.200, 1982.525–36, R 7797–98 (paratypes; Mazumbai FR II), 1982.537–540 (paratypes; Shume-Magamba FR I), 1982.541 (paratype; Balangai FR), 2005.1336-42 (Mazumbai FR I); CAS 168820–21, 168825–27 (Baga II FR), 168823–24 (Mazumbai FR II); MCZ A-13166 (paratype; Philipshof); ZMUC R7731–68, R361395, R77837, R771060 (Mazumbai FR II).

Remarks: In contrast to what Channing and Howell (2006) reported, we know of no record of this species outside the West Usambara (Poynton & Loader, 2008). There is a radiation of medium- to large-sized *Arthroleptis* across the EAM (Blackburn, 2008; Poynton et al., 2008), and distinguishing species can be difficult (Poynton & Loader, 2008). Poynton and Loader (2008) show that the *A. tanneri* type was distinguishable from other species on the basis of head/tibia ratio, and Blackburn (2008) demonstrated that *A. tanneri* was genetically divergent from *A. affinis*, *A. nikeae*, and *A. reichei*, possibly not even forming a clade with these other EAM species.

***Arthroleptis xenodactyloides* Hewitt, 1933**

Records—**WEST USAMBARA**, CAS 168829 (Baga II FR), 200513–515 (Mazumbai FR II); FMNH 250446–51 (Ambangulu FR VII); **SOUTH PARE**, BMNH 2005.987–89 (Nakombo River), 2005.990–93 (Pare Forest), 2000.733 (Chome FR I); FMNH 251406–09, 251418 (lot of seven specimens), 251419–20 (lot of 12 specimens), 251421 (lot of 14 specimens), 251422–35 (Chome FR IV), 251443–44 (Gonja FR), 251863–68 (Chome FR V); MTSN 7545–46 (Chome FR II).

Remarks: *Arthroleptis xenodactyloides* is the most widespread species of miniature *Arthroleptis* in East Africa and has one of the largest elevational ranges of any East African frog (Poynton et al., 2007). A recent phylogeographic study has highlighted that populations of *A. xenodactylodes* from the northernmost EAM, including the Usambara Mountains, form a clade that is sister to populations of most southern mountains (e.g., Uluguru, Malundwe, Udzungwa) and Pemba Island (Blackburn & Measey, 2009). There is little genetic divergence between populations of *A. xenodactyloides* from the West and East Usambaras, but populations from South Pare are yet to be included in phylogeographic analyses.

***Arthroleptis* sp. ?nov.**

Records—**WEST USAMBARA**, CAS 200516–17 (Mazumbai FR II).

Remarks: These two specimens were collected in pitfall buckets in Mazumbai FR at an elevation of ca. 1400–1600 m. Both specimens are small; CAS 200516 and 200517 have snout–vent lengths of 13.9 and 15.5 mm, respectively. These frogs exhibit the typically smooth skin of *Arthroleptis*, but, unlike at least other *Arthroleptis* in the EAM, the skin of the body, head, and limbs is covered with many small, well-spaced spiny tubercles. Another notable feature is the supratympanic band, which overlies a small and near indistinct tympanum, is solid, and forms an elongate ventrally directed C with no spots trailing anterior or posterior from it. The inner metatarsal tubercle is small and ovoid, bordering on globose, and there are no supernumerary tubercles on the plantar surface. These specimens are clearly distinct morphologically from other *Arthroleptis* in the EAM and East Africa in general. However, both specimens are juveniles, or at least immature adults, and

FIG. 3. Photographs of some amphibians from the northwestern Eastern Arc Mountains; clockwise from top left, *Callulina stanleyi* (Chome FR), *Nectophrynoides vestergaardi* (Mazumbai FR), *Scolecomorphus* cf. *vittatus* (Kindoroko FR), and *Leptopelis* cf. *parkeri* (Chome FR).

we refrain from describing this taxon as a new species until more material becomes available.

***Leptopelis flavomaculatus* (Günther, 1864)**

RECORDS—**WEST USAMBARA**, FMNH 275635–36 (Ambangulu FR V).

***Leptopelis parkeri* Barbour and Loveridge, 1928**

RECORDS—**WEST USAMBARA**, BMNH 2005.1365–66 (Mazumbai FR II); CAS 168784–813 (Mazumbai FR II), 168814 (Baga II FR); FMNH 250483, 248025–26 (Ambangula FR III); MHNG 2620.097–098, 2687.065–066 (Mazumbai FR II); ZMUC R7737–84 (Mazumbai FR II); **SOUTH PARE**, MHNG 2640.074–75 (Chome FR I); MTSN 7550–55 (Chome FR VI).

REMARKS: The West Usambara material matches the description of *L. parkeri* (Barbour & Loveridge, 1928). All West Usambara FMNH specimens are females. The dorsum in FMNH 248025–26 is very darkly colored, whereas in FMNH 250483 it is pale yellow and almost white. South Pare material is noticeably different in terms of the coloration and patterning (see Fig. 3). The South Pare material might represent a previously unrecognized species of *Leptopelis*.

***Leptopelis vermiculatus* (Boulenger 1897)**

RECORDS—**WEST USAMBARA**, BMNH 1982.582 (Mazumbai FR IV), 1982.583–86 (Ambangulu FR VIII), 2005.1367–68 (Mazumbai FR II); CAS 161373 (Ambangulu FR II), 168813 (Mazumbai FR II); FMNH 275623 (Mazumbai FR III); MHNG 2620.091–93, 2687.071–72 (Mazumbai FR II); USNM 226810 (Ambangulu FR VIII); ZMUC R77385–90 (Mazumbai FR II).

Family Brevicipitidae

****Breviceps fichus* Channing and Minter, 2004**

RECORDS—**WEST USAMBARA**: *Call recorded, no specimen taken (1500 m, near the [Tanner's] house, close to Mazumbai FR, 2 December 2005—Alan Channing, pers. comm.).

REMARKS: Although no specimens have yet been collected, this record is a very significant extension because it would extend the known distribution of *Breviceps fichus* more than 400 km to the northeast (Channing & Minter, 2004; Channing & Howell, 2006). A record of *B. mossambicus* by Mertens (1937) was referred to *B. fichus* by Channing and Minter (2004) but then dropped from the distributional map of Channing and Howell (2006), suggesting that *B. fichus* is indeed restricted to the EAM.

Callulina

Recent work on the brevicipitid genus *Callulina* demonstrates that new faunal surveys and detailed taxonomic study can quickly change long-standing patterns of species diversity and biogeography. The first species of *Callulina* was described by Nieden (1911) based on material from Amani in the East Usambara and has since been identified from many localities throughout the EAM (Channing & Howell, 2006). More than 80 years later, a second *Callulina* species, *C. kisiwamsitu*, was described by de Sá et al. (2004). This description was based on material from the West Usambara and was quickly followed by descriptions of four more *Callulina* species, all from the northernmost EAM, by Loader et al. (2009, 2010). These recent taxonomic works quintupled the species diversity in the genus and provided the first hints that the northernmost EAM is a center of speciation in *Callulina*. Taken together, recent work on *Arthroleptis* and *Callulina* suggests that similar high levels of diversity may be found in other genera when given appropriate and detailed taxonomic study.

***Callulina kisiwamsitu* de Sá, Loader, and Channing, 2004**

Records—**WEST USAMBARA**, BMNH 1974.21–23 (Mazumbai FR II), 1982.588–89 (Mazumbai FR II), 1982.590–92 (Shume-Magamba FR I), 1986.595–99 (Mazumbai FR II), 2002.45–46 (Mazumbai FR II), 2002.47 (Ambangulu FR I); CAS 160078, 168806–09 (Mazumbai FR II), 168815–19 (Ambangulu FR II); MCZ A-13632–33, A-13635 (Philipshof), A-138534 (Mazumbai FR I); MHNG 2621.15–18 (Mazumbai FR II); ZMUC R0937–47 (Mazumbai FR II).

***Callulina laphami* Loader, Gower, Ngalason, and Menegon, 2010**

Records—**NORTH PARE**, BMNH 2002.37–41, 2005.951; CAS 225134–35 (Kindoroko FR); MTSN 7123, 8609, 8611–14, 8621–22, 8632, 8640–41, 8648, (Minja FR).

***Callulina shengena* Loader, Gower, Ngalason, and Menegon, 2010**

Records—**SOUTH PARE**, BMNH 2008.465-466 (Chome FR VI); FMNH 251849–52, 255881–82 (Chome FR V); MTSN 9285, 9288–90 (Chome FR VI).

***Callulina stanleyi* Loader, Gower, Ngalason, and Menegon, 2010**

Records—**SOUTH PARE**, BMNH 2000.207 (Chome FR I), 2008.467–68 (Chome FR II); FMNH 251381–84 (Chome FR IV); MTSN 7541–42, 7544, 7559 (Chome FR II).

Family Bufonidae
***Amietophrynus brauni* (Nieden, 1911)**

Records—**WEST USAMBARA**, FMNH 248051 (Ambangulu FR II), 248052 (Ambangulu FR V); MCZ A-12445 (Bumbuli), A-138458, A-138507, A-138516–19 (Ambangulu FR VII).

***Amietophrynus gutturalis* (Power, 1927)**

Records—**WEST USAMBARA**, MCZ A-12452–54 (Bumbuli), A-138524 (Ambangulu FR VI); **SOUTH PARE**, BMNH 2000.734 (Chome FR I), 2005.898 (Pare Forest); FMNH 251385–86 (Chome FR IV), 251446 (Gonja FR).

***Nectophrynoides vestergaardi* Menegon, Salvidio, and Loader, 2004**

Records—**WEST USAMBARA**, BMNH 1982.499–501, 1982.509–12, 1982.514–17 (Shume-Magamba FR I), 2005.1340 (West Usambara); CAS 161371 (Shume-Magamba FR I), 169381–82 (Baga II FR), 200518 (Mazumbai FR II); FMNH 251445, 248020–22, 250604–09 (Ambangulu FR IV); ZMUC R131228-48 (Mazumbai FR II).

Family Hyperoliidae
***Afrixalus fornasini* (Biaconi, 1849)**

Records—**WEST USAMBARA**, CAS 169250–52 (Mazumbai FR II).

***Afrixalus uluguruensis* (Barbour and Loveridge, 1928)**

Records—**WEST USAMBARA**, BMNH 1974.240–41 (Mazumbai FR, not found in the collection but identified by A. G. C. Grandison), 1982.567 (Mazumbai FR II), 2005.1334–35 (Mazumbai FR II); CAS 169266–74, 169937 (Mazumbai FR II); FMNH 276749, 276750, 278936 (Mazumbai FR I); MCZ A-13321 (Bumbuli); MHNG 2620.080–82 (Mazumbai FR II); ZMUC R77268–87 (Mazumbai FR II).

***Hyperolius argus* Peters, 1854**

Records—**WEST USAMBARA**, BMNH 1982.565 (Ambangulu FR VIII).

***Hyperolius mitchelli* Loveridge, 1953**

Records—**WEST USAMBARA**, FMNH 274532–36, 275025–29 (Ambangulu FR VI); **NORTH PARE**, MTSN 8643 (Kindoroko FR).

***Hyperolius* cf. *parkeri* Loveridge, 1933**

Records—**WEST USAMBARA**, FMNH 274550 (Ambangulu FR VI).

Remarks: This juvenile specimen was light green in life but is in a poor condition of preservation. DNA from the specimen was sequenced and demonstrates that it is conspecific with confirmed specimens of *Hyperolius parkeri* from Man'gula in the Udzungwa Mountains. Genetic data from this specimen was 1% divergent from that of positively identified specimens for the mitochondrial NADH dehydrogenase 2 (ND2) gene and two nuclear genes (pro-opiomelanocortin [POMC] and cellular myelocytomatosis c-myc; L. Lawson, unpubl. data). Molecular sequences are deposited in GenBank under the FMNH ID 274550.

***Hyperolius puncticulatus* (Pfeffer, 1893)**

Records—**WEST USAMBARA**, BMNH 1974.260–68, 1974.323–37 (Mazumbai FR II), 2005.1364 (Mazumbai FR II); CAS 169105–248 (Mazumbai FR II); FMNH 274526–30. LL18800–02, 18808–09, and 18811–13 are at UDSM to be catalogued (Mazumbai FR I), FMNH 274506–07, 274405, 274508–13. LL18824-18827 are at UDSM to be catalogued (Shume-Magamba FR II), FMNH 275001–10, 275011–15 (Ambangulu FR VI); MCZ A-13291, A-132675–85, A-13286–95 (Bumbuli); MHNG 2621.009–14, 2688.018 (Mazumbai FR II); ZMUC R77325–55 (Mazumbai FR II).

Hyperolius pusillus **(Cope, 1862)**

RECORDS—**WEST USAMBARA**, FMNH 248041 (Ambangulu FR IV).

Hyperolius tanneri **Schiøtz, 1982**

RECORDS—**WEST USAMBARA**, CAS 169263–65 (Mazumbai FR II); FMNH 274287–88 (Mazumbai FR I), 274289 (Shume-Magamba FR II); ZMUC R077356–72 (Mazumbai FR II).

Hyperolius glandicolor **Peters, 1878**

RECORDS—**SOUTH PARE**, BMNH 2000.735 (Chome FR I); **NORTH PARE**, MTSN 8635–36 (Kilomeni Mission).

Kassina maculata **(Duméril, 1853)**

RECORDS—**WEST USAMBARA**, BMNH 1974.401 (Mazumbai FR II).

Family Microhylidae
Hoplophryne **sp.**

RECORDS—**WEST USAMBARA**, FMNH 250472–75 (Ambangulu FR IV).

REMARKS: Three juvenile specimens (FMNH 250473–75; 11.8–14.0 mm snout–vent length) are tentatively identifiable to the genus *Hoplophryne* but show differences from other members of the genus (*H. rogersi* and *H. uluguruensis*; Barbour & Loveridge, 1928). FMNH 250472 is entered in the catalogue but has been returned to the donor institution (University of Dar es Salaam). Each of these specimens has long and gracile limbs. Furthermore, there are distinct and symmetrically arranged spines present on the dorsal surface; these spines are mainly concentrated posteriorly in FMNH 250475. Further assessment of these specimens will be required, but given the differences with described *Hoplophryne* species, these specimens likely represent a morphologically distinct and undescribed species.

Family Phrynobatrachidae
Phrynobatrachus krefftii **Boulenger, 1909**

RECORDS—**WEST USAMBARA**, BMNH 2005.1370–72 (Mazumbai FR II), 1974.64–95 (Mazumbai FR II); CAS 168727–83, 169380 (Mazumbai FR II); FMNH 272048 (Shume-Magambo II); MCZ A-12776–78 (Bumbuli), A-138286, A-138296–309, A-138455–57 (Mazumbai FR I), A-138310–15, A-138364, A-138551 (Ambangulu FR VI); MHNG 2621.019–020 (Mazumbai FR II).

REMARKS: FMNH 272048 is a juvenile specimen lacking the distinctive yellow throat of adult *P. krefftii*; thus, there is some uncertainty regarding its identity.

Phrynobatrachus natalensis **(Smith, 1849)**

RECORDS—**NORTH PARE**, MHNG 2624.073 (Kindoroko FR)

Phrynobatrachus **sp.**

RECORDS—**WEST USAMBARA**, BMNH 1974.158–69 (Mazumbai FR II).

REMARKS: The material was identified by Grandison as *P. minutus,* a species probably restricted to Ethiopia (B. M. Zimkus, pers. comm.). It resembles *P. ukingensis* in the presence of a light subtympanic band in most specimens, but the gular region is only lightly darkened. The presence of a clearly visible tympanum and slight but discernible expansion of digital tips into discs excludes this material from *P. schlefferi.*

Family Pipidae
Xenopus **cf.** *victorianus* **Ahl, 1924**

RECORDS—**WEST USAMBARA**, BMNH 1982.495 (Shume-Magamba FR I); MCZ A-12384–87 (Bumbuli).

REMARKS: There is doubt regarding the taxonomic status of *Xenopus* populations from the EAM. Specimens from the MCZ (A-12384–87; B. M. Zimkus, pers. comm.) reportedly have the following features: (1) claws present only on the first three toes and (2) a subocular tentacle less than half the diameter of the eye. Because of the relative length of the subocular tentacle, these specimens differ morphologically from *X. muelleri* (Kobel et al., 1996). While superficially resembling *X. victorianus,* the fifth toe of the West Usambara specimens is approximately the same length as the crus, whereas in *X. victorianus,* the fifth toe is somewhat longer than the crus (Kobel et al., 1996). Detailed taxonomic study will be required on *Xenopus* across the EAM to understand the status of each species. Because other montane regions in sub-Saharan Africa contain a number of endemic *Xenopus* species (e.g., Kobel et al., 1980; Loumont & Kobel, 1991; Evans et al., 2008), it would be unsurprising if this is similarly true for the EAM.

Family Ptychadenidae
Ptychadena anchietae **(Bocage, 1868)**

RECORDS—**WEST USAMBARA**, MCZ A-138527 (Ambangulu FR VI); **SOUTH PARE**, FMNH 251439–40 (Gonja FR), 251370–72 (Chome FR IV); MTSN 7547 (Chome FR II); **NORTH PARE**, MHNG 2624.066–067, 2624.070–73 (Kindoroko FR).

Family Pyxicephalidae
Amietia angolensis **(Bocage, 1866)**

RECORDS—**WEST USAMBARA**, BMNH 1974.132–44, 1982.558 (Mazumbai FR II); CAS 168828 (Handei Village Pond), 168719–26, 168804, 168830 (Mazumbai FR II); FMNH 248039 (Ambangulu FR IV); MCZ A-12661–65 (Bumbuli); **SOUTH PARE**, BMNH 2000.736 (Chome FR I); FMNH 251373–74 (Chome FR III), 251375–80 (Chome FR IV); MHNG 2619.094 (Chome FR I); MTSN 7548 (Chome FR II); **NORTH PARE**, MHNG 2624.068–69 (Kindoroko FR).

REMARKS: Several authors have suggested that there are probably cryptic species within those populations currently referred to as *Amietia angolensis* based on morphological grounds (Drewes & Vindum, 1994; Pickersgill, 2007). *Amietia angolensis* has a somewhat anomalously large elevational range (e.g., Poynton, 2003), which raises the possibility that lowland and highland populations are not conspecific. Although previous works have not dealt explicitly with material from the northern EAM, we leave open the possibility that cryptic species of *Amietia* might exist in the EAM.

Strongylopus fuelleborni **Nieden, 1911**

Records—**WEST USAMBARA**, BMNH 1929.6.1.6 (Philipshof); MCZ A-12715, A-12732–35 (Philipshof).

Remarks: There has been recent disagreement regarding the taxonomy of *Strongylopus* in the EAM and adjacent volcanic mountains of Mts. Kilimanjaro and Meru (Channing & Davenport, 2002; Poynton, 2004; Clarke & Poynton, 2005). The taxonomic and phylogenetic relationships of *Strongylopus* in the northern EAM to those of the volcanic mountains are an important area for future research.

Order Gymnophiona
Family Caeciliidae
***Boulengerula* cf. *boulengeri* Tornier, 1896**

Records—**WEST USAMBARA**, BMNH 2005.1343–48 (Lushoto), 2005.1349–56 (Ambangula FR I), 2005.1357–63 (Mazumbai FR II); CAS 168822 (Mazumbi FR II); ZMUC R361289, R361291–93 (uncertain locality – see below), 361393 (Mazumbai FR II).

Remarks: The existence of an undescribed new species from West Usambara has been suggested based on morphological and molecular data (Vestergaard, 1994; Channing & Howell, 2006; Loader et al., 2011). At least some West Usambara specimens referred to here as *B.* cf. *boulengeri* have more annuli and vertebrae than those from East Usambara. In addition, genetic distances between West and East Usambara samples provide some support for the suggestion of a new species (Loader et al., 2011). However, further detailed taxonomic study is required. There are uncertainties regarding the locality data for a series of specimens in Copenhagen collections (ZMUC-R 361291–93). This collection of *Boulengerula* material was made by M. Anderson, J. Rasmussen, and M. Vestergaard in East Usambara (Amani Nature Reserve) and West Usambara (Mazumbai FR) in consecutive days in September 1992. Field notes accompanying the amphibian material were lost and this has raised doubts about the exact provenance of these specimens.

Family Scolecomorphidae
***Scolecomorphus* cf. *vittatus* (Boulenger, 1895)**

Records—**WEST USAMBARA**, CAS 168810–11 (Mazumbai FR II), 168812 (Baga II FR); FMNH, 248043-46, 250532, 250589, 251437 (Ambangulu FR IV); MCZ A-12189 (Philipshof); ZMUC R0265, R361273, R361286, R361288, R0197 (Mazumbai FR II); **SOUTH PARE**, BMNH 2005.902–914 (Chome FR I); MTSN 7549 (Chome FR II); **NORTH PARE**, BMNH 1986.609 (Kifula Village, Ugweno), 2005.954–85 (Kindoroko FR); CAS 159945–64 (Kifula Village, Ugweno); MTSN 8619–20, 8631, 8633–34, 8637–39 (Kindoroko FR), 8642, 8644–45, 8647, 8649 (Minja FR); UMMZ 172066-7 (Kifula Village, Ugweno); USNM 226753 (Kifula Village, Ugweno).

Remarks: The diversity of scolecomorphid caecilians across the Usambara and Pare Mountains is currently being assessed (Loader, unpubl. data). It is likely that new species will be described from this material. Differences between populations in this region were implied in Nussbaum's (1985, pg. 30) review of material from North Pare: "Adults from the North Pare Mountains, to the northwest of the Usambara, have more extensive dark dorsal bands, which extend ventrolaterally past the midlateral line. The ventrolateral, light coloration is a duller cream."

Discussion

Table 1 summarizes the species for which records are known from the West Usambara, South Pare, and North Pare Mountains. The records presented here substantially increase the knowledge of species distributions in this East African biodiversity hotspot. In total, West Usambara has 33 species known (four endemic), South Pare 12 species (three endemic), and the North Pare eight species (one endemic). Our assessment was unable to confirm the presence of *Arthroleptis adolfifriederici* and *Petropedetes* [*Arthroleptides*] *martiensseni*, both recorded by Channing and Howell (2006). Until specimens can verify the presence of these species, it should be concluded that these are absent from the West Usambara. It should be noted that any comparisons with other Eastern Arc fragments should consider the complexity of species turnover between highland and lowland areas (Poynton et al., 2007). Some of the records given in our list include species that are usually treated as being part of the fauna of surrounding lowlands and are noted in Table 1 (footnote 3; e.g., *Amietophrynus gutturalis*). Therefore the highland fauna of the West Usambara and Pares is less species rich than indicated and would be reduced if some of the lowland species that penetrate highland forest habitats are excluded. Intensive sampling across the altitudinal distribution of species in these areas would be required before this could be adequately treated.

Patterns of species diversity across these mountains show a gradual southeast-to-northwest decline in numbers from the West Usambara to North Pare. This is also mirrored in the number of endemic species to these areas (see Table 1). This trend is more marked if species diversity in the East Usambara is also considered (Poynton et al., 2007). If the data from IUCN et al. (2009) are used to refine the species distribution maps of Channing and Howell (2006), then the following are sub-montane or montane species found in the East Usambara but apparently absent in the West Usambara or Pares: *Arthroleptis xenodactylus*, *Petropedetes* [*Arthroleptides*] *martiensseni*, *Breviceps mossambicus*, *Hyperolius spinigularis*, *Hoplophryne rogersi*, *Leptopelis barbouri*, *L. uluguruensis*, *Nectophrynoides tornieri*, *Parhoplophryne usambarica*, *Probreviceps macrodactylus*, and *Ptychadena oxyrhychus*. Notably, this list includes three genera (*Petropedetes*, *Parhoplophryne*, and *Probreviceps*) for which there are currently no records from the West Usambara or Pares. One likely reason for the differences in species richness and taxonomic diversity is the unequal sampling across these habitats, with most surveys focused historically in the East and West Usambara. If this is the major source of difference, then it suggests that more diversity remains to be discovered in the West Usambara and Pares. However, apart from the unequal surveying, other factors are likely to be significant in explaining the differences in amphibian diversity across the northwestern EAM. Forest area decreases sharply from West Usambara to North Pare (323, 139, and 26 km^2, respectively; Table 2), and this area effect likely contributes to differences in species richness (as supported by Burgess et al., 2007). The climate is also increasingly drier along this cline (Burgess et al., 2007), and therefore the suitability of habitats for amphibians is expected to be proportionately reduced. Other taxonomic groups (e.g., trees, birds, and mammals) also reveal similar relative differences between these areas, suggesting a common biogeographic pattern (Burgess et al., 2007). Although we suspect many other species await discovery, we predict that

TABLE 1. Species list for amphibians of the West Usambara and Pare Mountains.

	West Usambara	South Pare	North Pare
Anura			
Arthroleptidae			
Arthroleptis affinis	X		
Arthroleptis anotis		X[1]	
Arthroleptis fichika	X	X	X
Arthroleptis lombergi	X[2]		
Arthroleptis stenodactylus	X	X	
Arthroleptis tanneri	X[1]		
Arthroleptis xenodactyloides	X	X	
Arthroleptis sp. ?nov.	X		
Leptopelis flavomaculatus[3]	X		
Leptopelis parkeri	X	X	
Leptopelis vermiculatus	X		
Brevicipitidae			
Breviceps fichus[3,4]	X		
Callulina kisiwamsitu	X[1]		
Callulina laphami			X[1]
Callulina shengena		X[1]	
Callulina stanleyi		X[1]	
Bufonidae			
Amietophrynus brauni	X		
Amietophrynus gutturalis[3]	X	X	
Nectophrynoides vestergaardi	X[1]		
Hyperoliidae			
Afrixalus fornasini[3]	X		
Afrixalus ulugurnensis	X		
Hyperolius argus[3]	X		
Hyperolius glandicolor[3]		X	X
Hyperolius mitchelli[3]	X		X
Hyperolius parkeri[3]	X		
Hyperolius puncticulatus	X		
Hyperolius pusillus[3]	X		
Hyperolius tanneri	X[1]		
Kassina maculata[3]	X		
Microhylidae			
Hoplophryne sp.	X		
Phrynobatrachidae			
Phrynobatrachus krefftii	X		
Phrynobatrachus natalensis[3]			X
Phrynobatrachus sp.	X		
Pipidae			
Xenopus victorianus[3]	X		
Ptychadenidae			
Ptychadena anchietae[3]	X	X	X
Pyxicephalidae			
Amietia angolensis[3]	X	X	X
Strongylopus fuelleborni	X		
Gymonphiona			
Caeciliidae			
Boulengerula boulengeri	X		
Scolecomorphidae			
Scolecomorphus cf. *vittatus*	X	X	X
Total (total endemic species)	33 (4)	12 (3)	8 (1)

[1] Endemic to this single fragment.

[2] Questionable status.

[3] Associated with lowland fauna.

[4] Not verified by a specimen.

differences between these areas might remain roughly the same when future studies survey these Eastern Arc forest fragments.

A general comparison of the amphibian communities reveals that the West Usambara and South Pare Mountains show similar species composition. A total of eight species are shared between West Usambara and South Pare, more than the five species shared between the Pares or the four among West Usambara and North Pare. Future taxonomic assessment of particular species (e.g., *Arthroleptis fichika, Scolecomorphus* cf. *vittatus*) is likely to further reduce the proportion of taxa shared between these mountains. The close biotic relationship between populations in the West Usambara and South Pare Mountains (and other northern Eastern Arc mountains such as the Taita or Shimba Hills) appears to be a

TABLE 2. Estimates of forest area, and elevational coverage for the East and West Usambara and South and North Pare Mountains.

	East Usambara	West Usambara	South Pare	North Pare
Forest area (km^2) according to Newmark (2002)[1]	413	547	333	151
Forest area (km^2) according to various other published sources (see notes)[1]	450	220	211	25
Forest area (km^2) according to standardized analysis of satellite imagery[1]	263	319	138	27
Estimate of forest area (km^2)[2]	263	323	139	26
Estimates of % change in forest cover across the Northern Eastern Arc Mountain blocks (Paleo. – 2000)[2]	−68.3	−86.3	−87.2	−92
Forest elevational coverage[1]	130–1506	1200–2200	820–2463	1300–2113

[1] Taken from Burgess et al., 2007.

[2] Taken from Hall et al., 2009.

pattern repeated in molecular studies that have been conducted across these areas (Bowie et al., 2004, 2006; Fjeldså et al., 2006; Kahindo et al., 2007; Blackburn, 2009a; Blackburn & Measey, 2009; Loader et al., 2009, 2010). Future molecular studies designed explicitly to test this pattern are required to determine the extent of this shared biogeography.

The diversity of amphibians in the Usambara and Pares highlights the conservation importance of these areas. Numerous endemic species from single forest fragments are known from these areas, including species of conservation concern (Loader et al., 2010). Remarkably, two *Callulina* species, stratified by elevation, are known in the South Pare in the Chome Forest Reserve (Loader et al., 2010). In addition to the new *Arthroleptis* species described here, these forest-restricted amphibian species, and the forest habitats they occupy, deserve conservation attention.

Land use changes in the Usambara Mountains have occurred over a prolonged period (Newmark, 2002). Early Iron Age sites demonstrate that lower portions of the montane zone (>1200 m) were occupied in West Usambara at least by the third century C.E. (Schmidt, 1988); use of forest products at these sites is clearly evident via the wood charcoal used in iron-smelting furnaces. In this and later time periods, mountain farmers in the Usambaras settled in and farmed montane and sub-montane zones where they cultivated a wide variety of crops, such as bananas (*Musa* spp.) that arrived because of trade with coastal sites integrated into oceanic trade routes (reviewed in Conte, 2004). Although the extent of forest present 2000 years ago was undoubtedly reduced in size before the nineteenth century, some of the most dramatic short-term changes in forest cover came in the late nineteenth and early twentieth centuries with the advent of German and, subsequently, British occupation (Conte, 2004). In the first half of the twentieth century, large amounts of forest were removed in the Usambara Mountains in order to plant economic crops on supposedly fertile soils (Conte, 2004). According to Hall et al. (2009), during the past 2000 years, the West Usambara have suffered a reduction in forest cover by 86%, the South Pare by 87%, and the North Pare by 92%. However, it should be noted that these recent comparisons by Hall et al. (2009) lump all deforestation from 2000 years ago to 1955 in the same time category, which makes it difficult to evaluate the degree of change that preceded the implementation of colonial forest management practices. Today there remains a strong concern for the conservation of the forest habitats in West Usambara (Goodman et al., 1995) and Pares (Hall et al., 2009), which have had dramatic historical reductions in size and for which our knowledge of the fauna is still woefully incomplete.

Gazetteer

North Pare Mountains

Kifula, Ugweno [3°37′30″S, 37°40′00″E].
Kindoroko FR [3°43′43.5″S, 37°39′16.1″E].
Minja FR [3°44′55.96″S, 37°38′47.09″E].
Kilomeni Mission [3°45′59.87″S, 37°38′59.73″E].

South Pare Mountains

Chome FR I [4°18′S, 37°53′E, 1800 m].
Chome FR II [4°19′41.382″S, 37°59′44.262″E].
Chome FR III, edge Chome FR, 5.5 km S Bombo (by air), near Kunza Village [4°19′S, 38°00′E, 1100 m].
Chome FR IV, 7 km S Bombo (by air) [4°20′S, 38°00′E, 1100 m].
Chome FR V, 3 km E, 0.7 km N Mhero [4°17′S, 37°55′40″E, 2000 m].
Chome FR VI, Shengena [4°17′42.907″S, 37°56′18.612″E].
Gonja FR, Higililu River [4°16′S, 38°02′E, 550 m].
Nakombo River [4°09′S, 37°56′E].
Pare Forest [4°09′S, 37°50′E].

West Usambara Mountains

West Usambara [4°43′S, 38°15′E, 1860 m]
Ambangulu FR I, BM [5°3′S, 38°24′E, 1250 m].
Ambangulu FR II, Tea Estate [5°4′S, 38°25′E, 1300 m].
Ambangulu FR III, Tea Estate, 14.5 km NW Korogwe [5°3′S, 38°23′E, 1250 m].
Ambangulu FR IV, Tea Estate, 12.5 km NW Korogwe [5°4′S, 38°25′E].
Ambangulu FR V, Tea Estate [5°5′S, 38°26′E, 1200 m].
Ambangulu FR VI, Tea Estate, 1102 m [5°3.266′S, 38°22.672′E].
Ambangulu FR VII, Tea Estate, 1252 m [5°3′57″S, 38°24′0″E].

Ambangulu FR VIII, Tea Estate [5°5′S, 38°26′E, 1200 m; Howell and Stuart, 1984].
Baga II FR [4°48′S, 38°27′E].
Balangai FR [4°55′59″S, 38°36′60″E].
Bumbuli [4°52′00″S, 38°27′60″E].
Handei Village Pond [unknown co-ordinates]
Lushoto [unknown co-ordinates].
Mazumbai FR I [4°49′45″S, 38°30′46″E].
Mazumbai FR II [4°49′S, 38°29.5′E].
Mazumbai FR III [4°48′S, 38°30′E, 1450 m].
Mazumbai FR IV [4°48′S, 38°29′E, 1500 m; Howell and Stuart, 1984].
Mombo [4°54′50″S, 38°17′29″E].
Philipshof [4°45′00″S, 38°30′00″E].
Shume-Magamba FR I [4°40′S, 38°10′E, 2134 m].
Shume-Magamba FR II [4°43′34″S, 38°14′58″E, 1920 m]
Shume-Magamba FR III edge [4°44′52″S, 38°17′51″E, 1642 m]

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